Penetrating Abdominal Trauma:

Spectrum of Disease in a Level I Trauma Centre

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Declaration

I, Anthony Sander, hereby declare that the work on which this dissertation/thesis is based is my original work (except where acknowledgements indicate otherwise) and that neither the whole work nor any part of it has been, is being, or is to be submitted for another degree in this or any other university.

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Abstract

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Background: Penetrating abdominal trauma (PAT) in South Africa represents a significant burden of disease. The current global trend has seen management shift towards selective conservatism. The purpose of this study is to describe the presentation, management and outcomes of PAT in a level I trauma unit, which routinely practices selective non-operative management (SNOM).

Methods: This was a retrospective descriptive audit of prospectively collected data. The Setting was Groote Schuur Hospital Trauma Centre, Cape Town, South Africa over 24 months (1 May 2015 to 30 April 2017). All patients presenting to the centre with PAT during the study period were included. The data captured and analysed included: basic demographics; admission vital signs; blood investigations; number of traumatic insults; penetrating wound positions; radiological investigations and interventions; indication for laparotomy; operative or nonoperative management; laparotomy findings: negative, therapeutic or non-therapeutic; abdominal visceral injuries and associated injuries. The Revised Trauma Score (RTS); Injury Severity Score (ISS); Penetrating Abdominal Trauma Index (PATI); and Kampala Trauma Score (KTS) were then calculated. The descriptive end points included the following: Length of hospital stay (LOS); ICU admission time; relaparotomy; readmission; mortality; and in-hospital complications.

Results: During the study period, 805 patients with penetrating abdominal trauma were managed. There were 502 (62.4%) and 303 (37.6%) patients with gunshot and stab wounds, respectively. The majority were young men (762 – 94.7%) with a mean age of 28.3 (95%CI: 27.7-28.9) years. The median trauma scores were as follows: RTS – 7.84 (IQR: 7.00-7.84);

ISS: 13 (IQR: 9-22), PATI: 6 (IQR: 1-14); and KTS: 14 (IQR: 14-15). Abdominal penetration was thoracoabdominal in 332 (41.2%), abdominal in 694 (86.5%), and pelvic in 192 (23.9%) patients. Immediate laparotomy was performed in 446 (55.4%) patients for: haemodynamic instability – 42 (5.2%); peritonism – 296 (36.8%); evisceration - 27 (3.4%); unreliable clinical evaluation – 24 (3.0%); and positive radiological findings – 57 (7.1%). There were 406 (50.4%) therapeutic laparotomies; 18 (2.3%) negative laparotomies; and 22 (2.7%) non-therapeutic laparotomies in the immediately operated group. Initial SNOM was performed in 359 (44.5%) patients, of which 208 (68.7%) sustained stab wounds and 151 (30.1%) gunshot wounds. Thirty-five (4.3%) patients failed SNOM and underwent delayed laparotomy. Should a policy of mandatory laparotomy have been implemented in this series, 206 (68.0%) SW and 163 (32.5%) GSW patients would have underwent unnecessary exploration. Overall non-fatal complications were 179 (22.2%) which were then further classified according to the Clavien-Dindo grading system. The median hospital stay was 4.5 (IQR: 3-7) and 7 (IQR: 5-12) days for SW and GSW, respectively. Overall 114 (14.2%) patients required admission to critical care unit for a median stay of 3 (IQR: 2-5) days. Total mortality was 7.2% (*n*=58).

Conclusion: Clinical evaluation (haemodynamic instability, peritonism and evisceration) was remarkably accurate in determining the need for early laparotomy. The unnecessary laparotomy rate of this group was 5.0% (negative: 2.3% and nontherapeutic: 2.7%) overall. Selective nonoperative management was performed in 44.5% of patients with a successful SNOM rate of 90.3%. The overall mortality was 7.2 %.

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I would like to thank my wife, who has had to share me with this project for the past 4 years..

Serena, thank you for your patience.

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To my supervisor, Professor Navsaria, thank you for the guidance with this project.

It has been a long road, but I am very proud of the product.

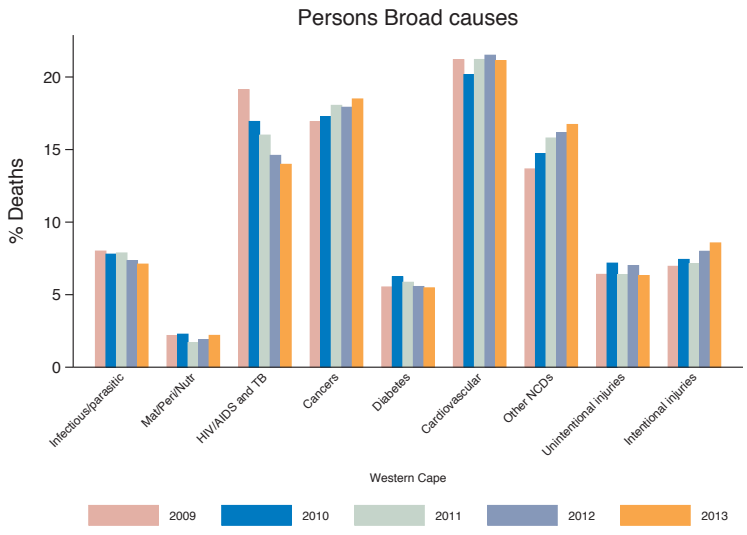
Chapter 1

Literature Review

Introduction

Penetrating abdominal trauma (PAT) in South Africa is amongst the most prevalent worldwide, representing a significant burden on the local health systems. In 2013 interpersonal violence was the ranked 3rd in all-cause mortality (15.8%) amongst males and 5th overall (9%) in Cape Town (Fig.1).[1] Current global trend in PAT has seen management shift towards selective non-operative management. This shift is made in small increments, with each clinical scenario being supported with evidence. Understanding the spectrum of disease of PAT with robust data is the first step in gaining perspective and equipping ourselves with the tools to assess and optimize management.

Fig. 1 - Trends in the percentage of deaths by broad cause disease category for all persons, Western Cape 2009 – 2013[1]



Historical background

Military background

Very few positives can be drawn from wars, although one such positive is the advances made during such times in trauma management. PAT is synonymous with wars, and have been with civilisation for as long as history has been recorded. However, until the 20th century, these injuries were managed almost exclusively non-operatively (rest, bloodletting and opium), with abysmal survival rates. This conservatism can be attributed to technological inadequacies and medical ignorance precluding a more aggressive approach, rather than choice. However, this began to change during the era of modern surgery, which was ushered in with the introduction of anaesthesia in 1846. This revelation, together with advances in antisepsis and surgical equipment, enabled surgical technique to flourish. By the time the Russian-Japanese War was fought, mandatory laparotomy was routinely practiced resulting in a significant reduction in mortality. At the beginning of World War I (WWI), trauma laparotomies could be performed with relative safety. However, surgical technique was not the only field of trauma management evolving during WWI. In fact, the improvement in rapid evacuation of injured patients, translated into fewer deaths on the battlefield, but operative mortality remained approximately 53%.[2] This reflected the greater severity of injuries reaching the surgeons, thereby challenging their skills. By WWII, improvements in surgical technique and the emergence of antibiotics reduced the perioperative mortality to 24%.[3,4] Improvements in perioperative care; blood transfusion technology; and rapid aerial evacuation during the Korean conflict and Vietnam War further reduced the operative mortality to 12% and 9%, respectively.(Table 1.)[4,5]

Table 1. Mandatory laparotomy mortality rates during conflict.

Conflict	Period	Mortality (%)
Russian-Japanese War	1904-1905	"mandatory laparotomy"
World War I	1914-1918	53
World War II	1939-1945	24
Korean War	1950-1953	12
Vietnam War	1955-1975	9

Civilian background

Many surgeons returning from military service after WWI brought the dictum of mandatory exploration of all penetrating abdominal injuries home with them to civilian hospitals. This served the victims of urban violence well, however, these surgeons noted that civilian weapons, mostly knives and low-velocity handguns were far less destructive than high-velocity military weapons. As many as 30% of these explorative laparotomies were non-therapeutic.[6] This led to the re-evaluation of the dogma of mandatory operative exploration of civilian PAT. It was in this context that the selective non-operative approach to civilian PAT was first published by Shaftan in 1960, but pioneered by D.S. Spreng Jnr's unpublished earlier work. In Shaftan's series, 180 consecutive abdominal trauma cases (which included 113 PAT) underwent selective non-operative management (SNOM). He reported a SNOM rate of 69%, negative laparotomy rate of 13.2% and overall mortality rate of 6%.[6] He concluded that abdominal examination was reliable and safe in determining the need for surgical exploration.

Years later in 1973, Nance et al. supported this with their findings, and took it further to include GSW. Nance found by analysing 2212 PAT records, that the 393 SW cases that

underwent SNOM reduced: the negative laparotomy rate from 53% to 11%; the complication rate from 14% to 8%; the hospital stay from 7.8 days to 5.5 days; and the overall laparotomy rate from 95% to 45%. Nance also analysed the 1032 GSW subgroup, and postulated that careful preoperative clinical assessment could have reduced the negative laparotomy rate from 13% to 9%. He also noted that the 52 GSW cases who were managed by observation alone, had no complications, comparted to 10% in the negative laparotomy group. Nance concluded by noting that SNOM could reduce the mandatory laparotomy rate by 60% and 18% for SW and GSW respectively.[7] This set the tone of things to come, and anticipated the modern approach to PAT.

The frequently forgotten contribution of SNOM for PAT by a South African colleague, Dr Aaron Stein, chief of the Baragwaneth Hospital Trauma Unit from 1962, warrants mention. In a multi-year audit of 646 patients, 150 of 340 patients with abdominal stab wounds (SW) were managed non-operatively with only 2 deaths and a 2.4% complication rate. It must be kept in mind that this work was published at a time when surgical dogma demanded mandatory exploration for all anterior abdominal SW. Clearly this concept has since proven to be safe; reliable; and in many centres; the standard of care.[8]

Epidemiology

Trauma causes around 10% of deaths worldwide.[9] The majority of these are blunt injuries, mainly due to motor vehicle collisions. Of the penetrating injuries, a significant proportion of these are due to military conflict and terrorism (especially high velocity gunshot as well as blast injuries) leaving the remainder as civilian events. Of these civilian events, gunshot wounds have a higher fatality (6.7%-10% for GSW compared to 1.4-1.9% for SW) despite stab wounds having a higher incidence.[7,10-13] The discrepancy in this incidence would be more pronounced were it not for the likely under-reporting of less severe abdominal stab injuries.

The incidence of PAT varies greatly across the world. Notable influences to this variation relates to the industrialization of developing nations; weapons availability; social and political unrest; and presence of current or recent military conflicts. Young males are the predominantly affected demographic group, constituting in excess of 90% of victims in some regions. [10,13-15]

The local epidemiology of PAT in South Africa is somewhat different, where up to 80% of all operations performed by trauma units are for penetrating injuries, which are almost exclusively performed on the civilian population. Interpersonal violence weighs heavily on society and the average South African is 12 times more likely to be murdered than a Westerner.[16] Stab wounds (SW) and gunshot wounds (GSW) contribute 15% and 29% to these fatalities, respectively.

Anatomy

Surface Anatomy

The surface of the abdomen can anatomically divided into 4 regions. This can assist the clinician determining the organs at risk of injury and thus guide subsequent management. They are as follows:

- Anterior Abdomen – Anatomical area extending from the costal margins superiorly to inguinal creases inferiorly, and between the anterior axillary lines laterally;
- Thoracoabdominal area – Extending from the superior border of 5th intercostal spaces anterior & 7th posterior to the costal margins inferiorly;
- Flank – Extending from the costal margin to the iliac crest, between the anterior and the posterior axillary lines;

- Back – Extending from the scapular tip to the iliac crest, between the left and right posterior axillary lines. Although not a separate abdominal region, the pelvis extends from the iliac crests superiorly to the perineum inferiorly.

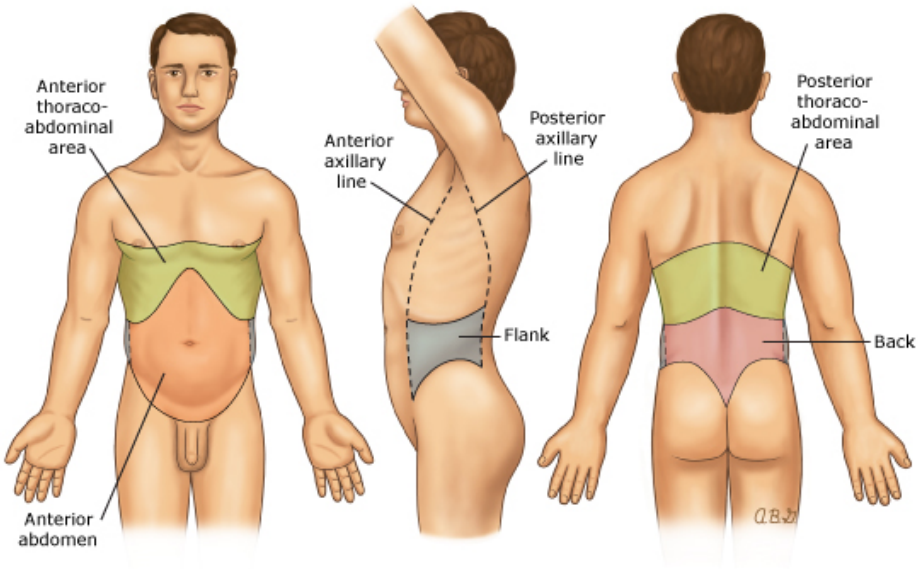


Figure 1. Anatomical zones of the abdomen by surface anatomy

Abdominal contents

Intraperitoneal organs of the abdomen include hollow viscous organs (stomach; ilium; jejunum; and transverse colon) and solid organs (spleen and liver).

Retroperitoneal contents include major abdominal vessels; duodenum; pancreas; ascending and descending colon; kidneys; ureters; urinary bladder and rectum.

Pathophysiology

Broadly speaking, PAT mechanism can be classified as ballistic or impalement.

Ballistic injuries may result from a variety of projectiles, penetrating the abdominal wall. Most commonly these projectiles are bullets, but explosive shrapnel and other missiles also satisfy this definition. The velocity; mass; shape; composition; behaviour of the missile; as well as

the proximity to the patient are important indicators of the extent of injury. Projectiles from low velocity weapons travel less than 335m/sec, whereas medium velocity travel 335-610m/sec and high velocity is defined as the projectile travelling greater than 610m/sec. The injuries from low velocity projectiles (such as seen with civilian handguns) is largely limited to the permanent cavitation (bullet tract) of the tissues. However, medium and high velocity projectiles (such as seen with assault and hunting rifles) contain far greater kinetic energy, resulting in a larger area of temporary cavitation to the tissues.[5]

Impalement injuries usually result from sharp objects, although with greater forces this becomes less important. Most commonly the inflicting instrument is a blade, especially from intentional trauma. The injury patterns are largely confined to the wound tract, with little occult injury to surrounding tissues.

Clinical Presentation

Differentiating stab from gunshot injuries is usually clear on the history. Further useful historical information includes the possible weapon, number of suspected insults, trajectory, as well as relevant patient background information.

Occult PAT is a rarity, and neurologically intact patients will usually present aware of the injury, rather than just complaining of the sequelae thereof. Unlike blunt abdominal trauma, should the patient present neurologically impaired, thorough examination of the abdomen is accurate in confirming the diagnosis of PAT. However, the clinician need to be vigilant to not miss concealed puncture wounds to the perineum or trans-corporal injuries.

During the initial assessment, meticulous attention must be given to exclude haemodynamic instability and peritonism. These would suggest solid organ and / or vascular structures; or hollow-viscous injuries, respectively. However, clinical speculating on the exact visceral

injuries pre-operatively, is grossly inaccurate. Evisceration and impalement, two of the other indications for mandatory laparotomy, require little skill to make the diagnosis of PAT.

Investigation and Management

Initial management

Given the urgent nature of trauma injuries, assessment and management should be conducted in parallel, rather than sequence. This should be simple and methodical, such as that proposed in Advanced Trauma Life Support™ (ATLS™) guidelines, which proposes an initial Primary Survey with adjuncts and resuscitation followed by the Secondary Survey with special investigations.[17]

Definitive management

Management of PAT usually involves resuscitation followed by assessment & attention to specific injuries. Following initial resuscitation, the decision needs to be made whether the patient must proceed for immediate surgery; further investigation or observation alone. Indications for immediate laparotomy include haemodynamic instability (indicating ongoing haemorrhage); peritonism (suggesting abdominal contamination); evisceration or impalement.[18-20]

Table 2. Indications for laparotomy in PAT

1. Haemodynamic instability
2. Peritonism
3. Visceral Evisceration
4. Impalement
5. Blood per rectum
5. Unreliable clinical examination (head / spinal trauma)
6. Radiologically confirmed bladder or ureteric injuries

Stab wounds

For stab wounds not meeting the aforementioned criteria, serial physical examination alone is both sensitive (87%-96.8%) and specific (93.5%-97.1%) for detecting significant intra-abdominal injuries.[15,20,21] Exceptions to this rule include: patients with an unreliable clinical picture (central or peripheral nervous system impairment); or where specific injuries need to be excluded. In these cases, further investigations may be indicated, however, a high incidence of nontherapeutic laparotomies can be expected in these cases.[18]

Gunshot wounds

Gunshot wounds not requiring immediate laparotomy usually necessitate further investigation before the decision can be made whether they can be managed non-operatively or not. Although mandatory laparotomy can be considered the conservative, safest approach, it is unnecessary in approximately 47% of cases.[12] It is for this reason that selective non-operative management is gaining momentum worldwide. Currently, haemodynamically stable & non-peritonitic abdominal GSW patients are candidates for CT scanning. Those with extra-peritoneal GSW trajectories can rarely be considered for discharge from the ED, and those with isolated solid organ injuries may be candidates for non-operative management.[12,22-26] Current published sensitivity and specificity for clinical assessment of abdominal GSW is 98% for each. Recently Navsaria even proposed a protocolised selective rather than mandatory CT scanning approach for abdominal GSW. [13]

Blueprint for non-operative management of PAT

Once all four major aforementioned indications for mandatory laparotomy have been excluded, the patient can be considered for SNOM, either immediately or following further investigation. SNOM rarely involves discharging the patient directly from the emergency department, and more commonly they are admitted for further observation.[18] During this admission the patient is kept nil per mouth, maintaining hydration with isotonic intravenous crystalloid solution. Anti-biotics are withheld, and analgesia administered as necessary.

Routine 4hrly vital sign observations, and regular serial clinical assessment (SCA) (preferably by the same clinician) must be carried out. After 24hrs of observation, should the patient's abdominal examination or haemodynamic status not deteriorate, the patient can be fed, and then considered for discharge home.[15,27] Further investigation during this admission are at the discretion the treating clinician. However, fever and a rise in WCC need to be interpreted with caution. Failure of NOM prompts operative intervention, and is usually signalled by peritonism; ongoing blood loss or concern of sepsis. Although an experienced trauma surgeon in a high volume centre is best equipped to make these clinical decisions correctly, NOM has been reported to be safe in lower volume centres too.[28,29]

Diagnostic adjuncts

In addition to non-invasive critical care monitoring, mandatory investigations that are included in the Advanced Trauma Life Support™ (ATLS™) primary survey include plain radiography (chest; pelvis and cervical spine); urine dipstix; and blood work (full blood count, electrolytes, renal function, B-HCG and arterial blood gases).[17] These form the protocoled approach to all trauma patients, and won't be discussed further in this text. The tailored diagnostic adjuncts of the secondary survey that are currently relevant to decision making of operative vs NOM in penetrating abdominal trauma however is paramount, and do deserve further discussion.

Plain radiography

Erect chest X-rays are mandatory for all thoracoabdominal injures, for assessment of injury to chest organs, but contribute little to assessment of the abdomen. Low dose full body plain radiographs (LODOX®) are however useful when the surface puncture wounds are marked with radio-dense makers. In such cases, in addition to the diagnosis of bony fractures, the markers assist in speculating projectile trajectories, and thus suspected injuries.

Focused abdominal ultrasonography in trauma (FAST)

FAST detects the presence of fluid (usually blood in the trauma setting) in the abdominal cavity, and proves especially useful in blunt trauma. In PAT however, its usefulness in deciding between operative or non-operative approach is limited to thoracoabdominal injuries. In Thoracoabdominal injuries, it's main purpose is to exclude pericardial fluid suggesting penetrating cardiac injury. However, some authors have suggested that the absence of intra-abdominal fluid is reassuring that the integrity of the diaphragm is intact, and mandatory abdominal inspection is unnecessary.[30,31]

Laparoscopy

Diagnostic laparoscopy has established its role in diagnosing occult diaphragm injuries in left sided thoracoabdominal trauma. The incidence of such injuries has been found by Murrey et al and Friese et al to be 24%, whereas Malherbe found it to be 29% in these patients.[32-34] Although open laparotomy remains the gold standard for diaphragmatic inspection, thoracoscopy or laparoscopy are safe alternatives. Whether to inspect the diaphragm via thoracoscopy or laparoscopy should be guided by on which side of the diaphragm the suspected injuries lie, and remains at the discretion of the surgeon.

For assessing intra-abdominal injuries, there is little evidence to support diagnostic laparoscopy is superior to SCA, especially since the latter is more cost-effective.[35] One exception may be to exclude a peritoneal breach in a neurologically impaired patient and thus avoid unnecessary laparotomies.[36]

Local wound exploration (LWE)

According to some authors, following a negative FAST, LWE that excludes peritoneal violation, allows a stable patient with PAT to the anterior abdomen to be discharged from the emergency department.[31,37] However, this approach is not widely accepted,

and the technique is especially problematic in the muscular, obese or intoxicated patients. [15,38]

Diagnostic peritoneal lavage (DPL)

DPL has been proposed as a tool to exclude diaphragmatic injuries in thoracoabdominal injuries when FAST is negative but diaphragmatic breech is still a concern. Should the DPL be negative, peritoneal breach can be excluded and the abdomen does not warrant further attention.[18,39] In anterior PAT with equivocal serial abdominal examinations / investigations, DPL findings positive for enteric contents warrants laparotomy, however sensitivity is low.

CT scan

Currently, CT scan is the most widely used and useful diagnostic modality for PAT. Although it's indication in SW is selective, the majority of GSW being considered for SNOM will undergo a CT scan.[40] Their usefulness here is revealing injures sustained as well as predict injuries not necessarily visualised, but anticipated by the bullets trajectory.[41,42] This is especially useful in tangential wounds, or GSW to the back and flank, when the FAST and DPL are of little use.[43-45] In 2015 Navsaria et al proposed a selective use of CT scans in abdominal GSW management. Absolute indications for imaging included right upper quadrant / right thoracoabdominal injury (to exclude liver injury); and haematuria (to exclude urogenital injury). Trans-pelvic GSW underwent a CT-cystogram. Additional indications included clinical concern from the managing surgeon. Of the SNOM group, 69.9% underwent CT scan as a part of their evaluation, but 30.1% required no CT scan at all, challenging the mandatory CT scanning for GSW being practiced worldwide. [13]

Damage control surgery (DCS)

DCS is the principle to abbreviate operative interventions in the unstable patient to allow for physiological stabilisation before definitive surgery is concluded. Although conclusive data is still lacking, there is a growing body of evidence that appropriate use can be lifesaving. However, if not applied appropriately, DCS can result in increased morbidity and mortality.[46-49]

Minimally invasive management adjuncts

The availability of angiographic embolization and percutaneous drainage of intra-abdominal collections has steadily increased the scope of NOM. Not only have the evolution of these techniques emboldened the experienced trauma surgeon to push the boundaries of NOM for more severe solid organ injuries, but is decreasing the failure rate thereof too.[50,51]

Contrasting approach to PAT in abdominal zones

Historically PAT to different abdominal regions were managed differently, with clinicians being more hesitant to treat back & pelvic injuries non-operatively. However, the evidence has refuted this, and today GSW and SW to the anterior abdomen; back; flank and pelvis can all be approached with the common principle described above. The abdominal region injured does never the less influence the choice of diagnostic adjuncts in their work-up.[18,24,27,30,31,37,43,52-57]

Non-operative management of solid organ injuries

There is increasing evidence that patients with penetrating trauma to the right upper quadrant / thoracoabdominal area or hematuria who do not have an indication for emergency laparotomy, should undergo CT imaging to exclude liver and kidney injuries. These injuries can be managed non-operatively with low morbidity and high success rate (>95%).[13,23,26,58] However NOM of penetrating abdominal trauma is still mainly based on the

findings of serial clinical examinations, irrespective of solid organ injury and cutting-edge CT technology.

Outcomes

Although all forms of penetrating abdominal trauma shares similarities in their presentation and management, when discussing outcomes (especially mortality rates), GSW and SW differ widely and warrant individual attention.[11,13]

Stab wounds

In the modern era, SNOM has grown in popularity and success amongst surgeons. In 2005 Navsaria et al published that they embarked on SNOM in 60.2% of all 186 SW presentations in their series. They reported a low SNOM failure rate (10.7% within this group and 6.5% overall), and 53.8% of the patients overall were successfully managed non-operatively. In 2011 Plackett et al reported similar SNOM rates (62.4%), although that was only reached by the end of their 16 year series, which illustrates the evolution of PAT management over the time. The unnecessary laparotomy rate in the early operative group however, remained stable at 14.2% but in the failed SNOM group, it too steadily decreased to 17.7% towards the end of the series. These trends were also demonstrated by Zafar et al's 6 year analysis of the North American National Database.[59] Navsaria et al reported an overall unnecessary laparotomy rate of 4.3% in the early laparotomy group, and 2.2% in the delayed laparotomy (failed SNOM) group. Morbidity rates for abdominal SW were 4.6% as reported by Plackett et al, with mean LOS of 6 days. The overall in-hospital mortality rates vary between 0.5%-1.9%, as per Navsaria and Plackett respectively.[10,15]

GSW

Following in the wake of the SW, the SNOM of GSW has become steadily more convincing. Velmahos et al and Navsaria et al have published the two largest single centre series

contributing to this argument.[12,13] After analysing 1856 GSW folders retrospectively, Velmahos reported that 42% initially underwent SNOM, with a success rate of 89.9%. Overall 4% (10.1% of SNOM) underwent delayed laparotomy, resulting in 35% of patients overall being managed without operation. The rate of unnecessary laparotomies was 14% of the operative group and 9% of the total cohort. The overall mortality rate was 10%, and 0.1% in the SNOM group.[12] Thirteen years later, Navsaria et al published on prospectively analysing 1106 abdominal GSW. They reported that SNOM was embarked on in 24.6% of all cases, with a success rate of 95.2%. Overall 1.1% (4.5% of the SNOM group) underwent a delayed laparotomy, meaning that overall 23.4% of cases were managed non-operatively. The unnecessary laparotomy rate was 3.5% of the operative group (2.6% overall). The mortality rate was 5.2% overall, and 0.4% in the SNOM group.[13]

Numerous publications show that patients being managed with selective non-operative management (SNOM) compare favourably to operative management (OM) as they have shorter admission periods and equivalent mortality. Despite, Zafar et al reporting an increased mortality rate in patients who under laparotomy after failed SNOM, a systemic review of the literature by Lamb et al in 2014 showed no difference in outcome between those undergoing early and late laparotomies. [11,59]

Conclusion

In summary, penetrating abdominal trauma remains a burden on the worldwide health resources. Current management trends are seeing advances at both ends of the injury spectrum. Damage control surgery is ensuring that about a third of even the most critically injured patients survive, whilst mandatory laparotomy is being overshadowed by SNOM as the superior strategy for managing many forms of PAT, including GSW. In fact, despite GSW having higher morbidity and mortality rates than SW, the accuracy of clinical assessment in determining the need for surgical exploration is excellent for GSW and SW.

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Chapter 2

Publication-ready Manuscript

Penetrating Abdominal Trauma:

Spectrum of Disease in a Level I Trauma Centre

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Abstract

Penetrating Abdominal Trauma:

Spectrum of Disease in a Level I Trauma Centre

Background: Penetrating abdominal trauma (PAT) in South Africa represents a significant burden of disease. The current global trend has seen management shift towards selective conservatism. The purpose of this study is to describe the presentation, management and outcomes of PAT in a level I trauma unit, which routinely practices selective non-operative management (SNOM).

Methods: This was a retrospective descriptive audit of prospectively collected data. The Setting was Groote Schuur Hospital Trauma Centre, Cape Town, South Africa over 24 months (1 May 2015 to 30 April 2017). All patients presenting to the centre with PAT during the study period were included. The data captured and analysed included: basic demographics; admission vital signs; blood investigations; number of traumatic insults; penetrating wound positions; radiological investigations and interventions; indication for laparotomy; operative or nonoperative management; laparotomy findings: negative, therapeutic or non-therapeutic; abdominal visceral injuries and associated injuries. The Revised Trauma Score (RTS); Injury Severity Score (ISS); Penetrating Abdominal Trauma Index (PATI); and Kampala Trauma Score (KTS) were then calculated. The descriptive end points included the following: Length of hospital stay (LOS); ICU admission time; relaparotomy; readmission; mortality; and in-hospital complications.

Results: During the study period, 805 patients with penetrating abdominal trauma were managed. There were 502 (62.4%) and 303 (37.6%) patients with gunshot and stab wounds, respectively. The majority were young men (762 – 94.7%) with a mean age of 28.3 (95%CI: 27.7-28.9) years. The median trauma scores were as follows: RTS – 7.84 (IQR: 7.00-7.84);

ISS: 13 (IQR: 9-22), PATI: 6 (IQR: 1-14); and KTS: 14 (IQR: 14-15). Abdominal penetration was thoracoabdominal in 332 (41.2%), abdominal in 694 (86.5%), and pelvic in 192 (23.9%) patients. Immediate laparotomy was performed in 446 (55.4%) patients for: haemodynamic instability – 42 (5.2%); peritonism – 296 (36.8%); evisceration - 27 (3.4%); unreliable clinical evaluation – 24 (3.0%); and positive radiological findings – 57 (7.1%). There were 406 (50.4%) therapeutic laparotomies; 18 (2.3%) negative laparotomies; and 22 (2.7%) non-therapeutic laparotomies in the immediately operated group. Initial SNOM was performed in 359 (44.5%) patients, of which 208 (68.7%) sustained stab wounds and 151 (30.1%) gunshot wounds. Thirty-five (4.3%) patients failed SNOM and underwent delayed laparotomy. Should a policy of mandatory laparotomy have been implemented in this series, 206 (68.0%) SW and 163 (32.5%) GSW patients would have underwent unnecessary exploration. Overall non-fatal complications were 179 (22.2%) which were then further classified according to the Clavien-Dindo grading system. The median hospital stay was 4.5 (IQR: 3-7) and 7 (IQR: 5-12) days for SW and GSW, respectively. Overall 114 (14.2%) patients required admission to critical care unit for a median stay of 3 (IQR: 2-5) days. Total mortality was 7.2% (*n*=58).

Conclusion: Clinical evaluation (haemodynamic instability, peritonism and evisceration) was remarkably accurate in determining the need for early laparotomy. The unnecessary laparotomy rate of this group was 5.0% (negative: 2.3% and nontherapeutic: 2.7%) overall. Selective nonoperative management was performed in 44.5% of patients with a successful SNOM rate of 90.3%. The overall mortality was 7.2 %.

Article Text

Introduction

Penetrating abdominal trauma (PAT) in South Africa is amongst the most prevalent worldwide, representing a significant burden on the local health systems. In 2013 interpersonal violence was the ranked 3rd in all-cause mortality (15.8%) amongst males in Cape Town.[1] Current global trend has seen management shift in small increments towards selective non-operative management (SNOM). Understanding the spectrum of disease of PAT with robust data is the first step in gaining this perspective, and subsequently equipping ourselves with the tools to assess and optimize management.

Although specific aspects of PAT have been studied, there is a paucity of comprehensive overviews of the problem. The purpose of this study is to describe the presentation, management, and outcomes of PAT in an urban, level I trauma centre, that sees a high volume of penetrating injuries.

Methods

Study Design: Retrospective descriptive audit of prospectively collected data on the HREC approved eTHR [electronic trauma health record] (HREC: R041 / 2014). Approval was obtained by the human research ethics committee (HREC REF:443/2017) of the University of Cape Town and Groote Schuur Hospital for this study.

Setting: Groote Schuur Hospital Trauma Centre, Cape Town, South Africa between 1 May 2015 to 30 April 2017. This unit treats all persons 13 years of age and older, and services mainly an urbanised population of approximately 2 million people.

Patient selection: All patients presenting to the centre with PAT during the study period were included in the study. The abdomen was defined as any penetrating wound between the 5th intercostal space and the pubis anteriorly, and the angle of the scapula down to the

creases of the buttock posteriorly. The abdomen was further subdivided in to the following zones (with borders) for descriptive purposes: anterior abdomen (from the xiphoid to pubis, between the anterior axillary lines); back / flank (posterior to the anterior axillary lines); thoracoabdominal (from the 5th intercostal space to the costal margin); and pelvis (iliac crests superiorly down to the perineum inferiorly). There were no exclusion criteria.

Data collection: All trauma patients' data entered prospectively into the Electronic Trauma Health Record (eTHR) system as part of the clinical record keeping process of the GSH Trauma unit was examined. Enrolment into this study involved identifying all patients with PAT and extracting the relevant data for analysis: basic demographics; admission of illicit drug use; presenting vital signs; blood investigations; number of penetrating traumatic insults; penetrating wound positions; presence of peritonism and/or evisceration; radiological investigations and interventions; indication for laparotomy; operative or nonoperative management; laparotomy findings: negative, therapeutic or non-therapeutic; abdominal visceral injuries and associated injuries. In cases where the patient had more than one indication for laparotomy, the most urgent indication was recorded, although the presence of peritonism on presentation was recorded separately. The Revised Trauma Score (RTS); Injury Severity Score (ISS); Penetrating Abdominal Trauma Index (PATI); Abbreviated Injury Scale (AIS); and Kampala Trauma Score (KTS) were then calculated to describe injury severity.[2-6] The descriptive end points included: hospital length of stay (LOS); Intensive Care Unit (ICU) admission. ICU LOS; relaparotomy within 30 days of admission; hospital readmission within 30 days of admission; in-hospital complications; and mortality. Complications were categorised according to the Clavien-Dindo classification system.[7] Multi-trauma injury patients were classified as having an AIS of greater than or equal to 3 in at least two organ systems.

An analysis was made comparing the two major mechanisms of injury (stab vs gunshot). Simple descriptive statistics was used to describe variables. Continuous data was

summarised using means and 95% confidence interval (95%CI) if normally distributed, whereas medians and interquartile range (IQR) was used for non-normally distributed data. Distribution of data was assessed qualitatively (graphically) and quantitatively (hypothesis tests). For inferential statistics, parametric tests were performed such as Chi-square tests or where appropriate the non-parametric equivalent. Furthermore, univariate logistic regression was performed to determine associations for clinically important outcomes and reported with odd ratios and 95% CIs. A *p*-value of <0.05 was considered statistically significant. Statistical analysis was done using STATA® 14 software.

Results

A total of 805 patients presented to the unit over the 2 year period with penetrating abdominal trauma. This cohort had a mean age of 28.3 (IQR: 27.7-28.9) years; 762 (94.7%) were male; and 454 (56.4%) admitted to illicit drug use. Unless specified, the results below refer to the combined PAT (SW and GSW).

Presenting characteristics and injury profile

Of the 805 cohort analysed, 303 (37.6%) were stab wounds (SW) and 502 (62.4%) were gunshot wounds (GSW). Abdominal wall penetration was thoracoabdominal in 332 (41.2%); abdominal (anterior and back / flank) in 696 (86.5%) and pelvic in 192 (23.9%) cases. Table 1 summarises the presenting features and injury profile. The median number of penetrating insults per patient was 2 (IQR: 1-5) for SW; and 2 (IQR: 1-3) for GSW (p=0.0013). This finding, together with the fact that any one injury insult may penetrate the abdominal wall twice (i.e. one on entering, and the other on exiting the body) account for the high number; and high relative percentage penetration; for each anatomical area. Seventy (23.1%) of the SW; and 298 (59.4%) of the GSW presented peritonitic (p<0.001). On comparison of the admission vitals and blood results, only the pulse rate, systolic blood pressure (BP) & white cell count (WCC) showed a statistical difference between the SW and GSW groups. The

three most commonly injured organs overall were: small bowel – 241 (29.9%); liver – 189 (23.5%) and colon – 177 (22.0%). Both omental and visceral evisceration was observed in 31 (3.9%) cases each, combining to give an evisceration rate of 7.7% in the total analysed cohort. Multi-trauma injuries were found in 106 (35%) of SW, and 223 (44.4%) of GSW patients (p=0.005).

Management

Table 2 summarises the management strategies and results thereof. Immediate laparotomies were performed in 95 (31.4%) of SW and 351 (69.9%) of GSW (p<0.001). In total 446 (55.4%) patients underwent immediate laparotomy for: haemodynamic instability - 42 (5.2%); peritonism – 296 (36.8%); unreliable clinical examination – 24 (3.0%); radiological findings – 57 (7.1%); and evisceration – 27 (3.4%). Thus, clinical assessment was adequate in determining the need for immediate laparotomies in 82% of PAT cases. The early laparotomy results were: negative – 18 (2.3%); non-therapeutic – 22 (2.7%); and therapeutic – 406 (50.4%). This amounts to an overall of 40 (5.0%) unnecessary laparotomies in this immediate laparotomy group. There were 15 (1.9%) injuries missed in total from these laparotomies.

Selective non-operative management (NOM) was implemented in 359 (44.5%) patients. This included 208 SW (68.7%) and 151 GSW (30.1%) (p<0.001). Overall 35 (4.3%) PAT patients underwent delayed laparotomy for: haemodynamic instability – 2 (0.3%); peritonism – 14 (1.7%); radiological findings – 10 (1.3%); and concern of sepsis – 9 (1.1%). One hundred and eighty-nine (62.4%) SW and 135 (26.9%) GSW patients were managed successfully non-operatively (p<0.001) to discharge. The results of the delayed laparotomies were: negative in 3 (0.4%); non-therapeutic in 2 (0.2%) and therapeutic in 30 (3.7%) cases who had NOM initially implemented. This amounts to a total of 5 (0.6%) patients undergoing unnecessary laparotomies in this NOM group.

Diagnostic laparoscopy was necessary in 19 (2.4%) cases of the total cohort. Of these: 13 (1.6%) excluded a diaphragmatic injury, 3 (0.4%) underwent a laparoscopic diaphragmatic injury repair; and 3 (0.4%) underwent an open diaphragmatic injury repair.

Additional investigation and management adjuncts included: emergency CT scanning in 355 (44.1%); damage control surgery in 63 (7.8%); and interventional radiology in 73 (9.1%) cases.

Outcomes

Two hundred and thirty-seven (29.4%) experienced one or more complications (up to and including death). Patients with GSW had significantly more non-fatal complications than those for SW (27.5 % vs 13.5%, $p<0.001$). The median length of hospital stay (LOS) was longer in patients with GSW by 2.5 days ($p<0.001$). One hundred and fourteen (14.2%) patients were admitted to the intensive care unit with a median ICU admission time of 3 days for both SW & GSW. As was the case with mortality; morbidity; hospital LOS; and ICU admissions, GSW was associated with a statistically significant higher relaparotomy rate when compared to SW. This overall PAT relaparotomy rate (within 30 days of admission) was 15.8% (*n*=76) of all initial laparotomies preformed, of which 6.7% (*n*=32) were unplanned. The readmission rate was 4.8% (*n*=39), and did not show any significant difference between GSW (4.3%) and SW (5.2%). The overall PAT mortality was 7.2% (*n*=58), consisting of 14 (4.6%) SW and 44 (8.8%) GSW (*p*=0.027). Table 3 details the full findings regarding outcomes of PAT.

Discussion

Routine explorative laparotomy of abdominal SW was generally the rule, until Shaftan's sentinel publication in 1960.[8] Using serial physical examination alone, numerous other

studies have further supported this selective approach with excellent results.[9-12] Various authors have noted that mandatory laparotomy policies for penetrating abdominal trauma result in unnecessary laparotomy rates ranging from 5.3% to 27% for GSW, and 23% to 53% for SW. [13,14] This implies that nearly a quarter of GSW, and almost half of all abdominal SW do not require a laparotomy, however our findings were closer to a third and two thirds, respectively. In this series of 805 patients with PAT, 95 (31.4%) SW and 351 (69.9%) GSW patients underwent immediate laparotomy, with a therapeutic laparotomy rate of 86.3% for SW and 92.3% for GSW. The overall sensitivity and specificity for clinical assessment in determining the need for laparotomy was 85% and 94% for SW; and 95% and 83% for GSW, respectively.

Here, we present one of the largest and most detailed series to date, describing SW and GSW side by side, in the same cohort. The demographics of both sub-groups show a young male preponderance, which is in keeping with worldwide trends in PAT.[15-18] On further assessment of the data, the differences in presentation; injury profile; management; and outcomes of the two groups becomes evident, however the value of SNOM in both groups remains constant. In fact, the accuracy of clinical evaluation and selective observation in determining the need for laparotomy here was 91% and 92% for SW and GSW, respectively.

Our SW subgroup shows a SNOM rate of 68.7%, with a 90.9% success rate. A total of 19 (6.3%) SW patients underwent delayed laparotomy, which were therapeutic in 78.9% of cases. Overall, 62.4% of all SW were managed successfully non-operatively. The unnecessary laparotomy rate in the early operative group was 4.3%, and 1.3% in the failed SNOM group. These findings compare favourably to the literature. Navsaria et al and Plackett et al published SW SNOM rates of 60.2% and 62.4% respectively.[16,19] Navsaria et al continued, noting a delayed laparotomy rate of 6.5%, resulting to 53.8% of all SW being managed non-operatively.[19] Furthermore, he reported an overall unnecessary laparotomy rate of 4.3% in the early laparotomy group, and 2.2% in the delayed laparotomy (failed

SNOM) group. Comparatively, Plackett's findings were significantly higher: 13.8% and 17.7% in these respective aforementioned groups. However it deserves mention that his series only included anterior abdominal stab wounds, and spanned 16 years, during which there was a steady decline in early operative rates to give the aforementioned results.[16,19] This trends was also demonstrated by Zafar et al's 6 year analysis of the North American National Trauma Database (NANTD).[15] This illustrates the evolution and progressive acceptance of SNOM in SW patients over time. [16,19]

Our GSW subgroup showed a 30.1% SNOM rate with a 89.4% success rate. A total of 16 (3.2%) patients underwent delayed laparotomy, which were therapeutic in 93.8% of cases. Overall 26.9% of GSW patients were managed non-operatively. Comparison of this can be made to publications by Velmahos et al, and Navsaria et al, which are the two largest single centre series detailing the SNOM of abdominal GSW.[17,18] Velmahos reported a far higher SNOM rate of 42%, with similar success (89.9%) and delayed laparotomy (4.0%) rates. However these comparisons must be interpreted with care, as their overall mean Injury Severity Scores (ISS) reported were lower than presented here. Navsaria et al's experience between 2004 to 2009 showed comparable results to ours. He described a lower SNOM rate (24.6%), but a higher success rate (95.2%), which it not surprising as they tend to have an inverse relationship to one another. In this series, of the patients managed with early laparotomy, we showed a 5.4% unnecessary laparotomy rate, comparable to the 9% and 2.6% reported by Velmahos and Navsaria respectively.[17,18] Zafar et al's retrospective analysis of the NANTD showed far lower rates of SNOM (22%), and success thereof (20.8%) too.[15] However he defined a SNOM failure as any delay to surgery greater than 4hrs, which likely explains much of the discrepancy between his and other publications.

There is a growing body of evidence that although morbidity is high, the appropriate use of damage control surgery (DSC) can be lifesaving.[20-23] In this series, it was utilised in 63 (7.8%) of overall PAT cases. The preponderance of GSW needing this abbreviated surgical

technique is significant when compared to SW (p=0.004), constituting 11.2% and 2.3% of their respective subgroups. This correlates well with the increased median ISS for GSW (16 IQR 9-25) compared to SW (9 IQR 4-17) here, indicating that the more severely injured cohort are managed more frequently with DCS. This trend continues from management into the outcomes thereof. Patients undergoing DCS for SW had a morbidity rate of 57% and a mortality rate of 29%, compared to 93% and 39% for GSW, respectively. This combined PAT mortality rate for DCS of 38%, is similar to Burch's DCS series where 33% of the 200 cases survived to discharge.[20]

Our findings for non-fatal complications amongst SW patients was 13.5%, higher than Nance (10.9%) & Plackett's (4.6%) series'. However, despite Plackett's lower complication rate, their hospital LOS of 6 days was still longer than presented here (4.5 days). Should we use only serious complications (Clavien-Dindo Grade 3 and 4) for our calculations, the non-fatal morbidity rate of SW would be 7.3%, which is more comparable to Plackett's, and lower than Nance's findings.[7,16,24] Similar to previous trends published, our GSW morbidity rate (27.5%) was higher than that of SW, comparing favourably to Nance's figures (35%) in the early SNOM era. [24]

Mortality rates of SW in this series is 4.6%, which is higher than the range of 0.4% to 1.9% published in previous literature.[9,15,16,19,24] Explaining this discrepancy is difficult, as few publications include all variables to make definitive conclusions. Furthermore, the GSW mortality of 8.8% here *does* compare favourably with international literature, which ranges between 5.4% and 12.5%.[9,17,18,24] Two possible reasons why this studies' SW and GSW mortality rates compare differently to the international literature are as follows: Firstly, at this institution (Groote Schuur Hospital) the prehospital service usually transfers GSW patients directly from the scene to the trauma unit, whereas SW are often routed via other health facilities, resulting in a delay to theatre which is specific to SW, and not GSW patients. Further analysis of the delays to surgery of this PAT data, may shed light on this point.

Secondly, SW patients in this cohort may be more severely injured than published elsewhere. The median ISS and number of abdominal stabs per patient was 9 and 2, respectively. However, the infrequence with which these are reported in the literature make meaningful comparisons difficult.

Should a policy of mandatory laparotomy have been implemented in this series, 206 (68.0%) SW and 163 (32.5%) GSW would have underwent unnecessary exploration, which is comparable to previous publications.[13,14,18] A strength of this paper is the direct, and detailed comparison of SW to GSW, in the same cohort. The robust numbers allowed for us to conclude that although GSW is a more morbid, and more often fatal injury, the general principles of SNOM hold true for both.

A limitation of this study is the lack of subgroup analysis, specifically of SNOM for the outcomes: LOS; morbidity; and mortality. Numerous publications have shown that patients being managed with selective non-operative management (SNOM) compare favourably to operative management (OM) as they have shorter admission periods and equivalent mortality.[17-19,25] Contrary to Zafar et al reporting failed SNOM to be associated with increased mortality, a subsequent systemic review of the literature by Lamb in 2014 showed no difference in outcome between those undergoing early and late laparotomies.[15,26] Future analysis of the SNOM complications in this study, would've contributed to this discussion.

Conclusion

In summary, penetrating abdominal trauma remains a burden on the worldwide health resources. Current management trends are seeing advances at both ends of the injury spectrum. Damage control surgery is ensuring that about a third of even the most critically injured patients survive, whilst mandatory laparotomy is being overshadowed by SNOM as the superior management strategy for many forms of PAT, including GSW. In fact, despite

GSW having higher morbidity and mortality rates, the accuracy of clinical assessment in determining the need for surgical exploration is 92% and 91% for GSW and SW, respectively. This series provides a valuable overview of how the two conditions compare side by side in a progressive era of selective non-operative management.

Ethical considerations

Conflict of interest: The authors have no conflict of interest regarding this manuscript.

Table 1. Presenting features and injury profile of 805 patients with PAT

Parameter		SW (*n*=303)	GSW (n=502)	*p-value*	Combined PAT (*n*=805)
	n (%)	303 (37.6%)	502 (62.4%)	N/A	N = 805
Patient Demographics					
	Age: Mean (95%CI)	28.1 (27.1-29.1)	28.4 (27.6-29.2)	NS	28.3 (27.7- 28.9)
	Male gender: *n* (%)	285 (94.1%)	477 (95.0%)	NS	762 (94.7%)
	Illicit drug use: *n* (%)	162 (53.5%)	292 (58.2%)	NS	454 (56.4%)
Admission physiology: Mean (95% CI)					
	Pulse	89.4 (87.3-91.5)	93.8 (91.9-95.7)	0.0037	92.2 (90.7-93.6)
	Systolic BP	126.4 (123.8-129.0)	130.1 (127.8-132.4)	0.0438	128.7 (127.0-130.5)
	pH	7.33 (7.32-7.35)	7.40 (7.33-7.35)	NS	7.34 (7.33-7.34)
	Lactate	3.25 (2.8-3.70)	2.89 (2.67-3.12)	NS	3.01 (2.8-3.22)
	Haemoglobin	12.1 (11.80-12.33)	12.1 (11.86-12.28)	NS	12.07 (11.90-12.23)
	WCC	14.1 (13.43-14.92)	16.0 (15.32-16.61)	0.0006	15.33 (14.83-15.82)
Trauma scores: Median (IQR)					
	Revised Trauma Score	7.80 (7.00-7.84)	7.84 (7.00-7.84)	0.0753	7.84 (7.00-7.84)
	Probability of survival %	97.4 (96.0-99.0)	97.2 (96.0-98.8)	0.0326	97.4 (96.0-99.0)
	Injury Severity Score	9 (4-17)	16 (9-25)	<0.001	13 (9-22)
	PATI Score	2 (0-6)	9 (4-20)	<0.001	6 (1-14)
	Kampala Trauma Score	14 (14-15)	15 (14-15)	NS	14 (14-15)
Multi-trauma Injuries	*n* (%)	106 (35.0%)	223 (44.4%)	0.005	329 (40.9%)
Injuries					
	Mechanism of Injury: *n* (%)	303 (37.6%)	502 (62.4%)	N/A	805 (100%)
	Insults per pt: Median (IQR)	2 (1-5)	2 (1-3)	0.0013	2 (1-4)
Peritonitic	*n* (%)	70 (23.1%)	298 (59.4%)	<0.001	368 (45.7%)
Evisceration: *n* (%)					
	Omental	20 (6.6%)	11 (2.2%)	<0.001	31 (3.9%)
	Visceral	29 (9.6%)	2 (0.4%)	<0.001	31 (3.9%)
PW position: *n* (%)					
	Thoracoabdominal - Lt.	91 (30.0%)	82 (16.3%)	<0.001	173 (21.4%)
	Thoracoabdominal - Rt.	60 (19.8%)	99 (19.7%)	NS	159 (19.8%)
	Back / Flank - Lt.	119 (39.3%)	154 (30.7%)	0.010	273 (33.9)
	Back / Flank - Rt.	64 (21.1%)	115 (22.9%)	NS	179 (22.2%)
	Anterior	73 (24.1%)	171 (34.1%)	0.002	244 (30.3%)
	Pelvic	13 (4.3%)	179 (35.7%)	<0.001	192 (23.9%)
Organs injured: No. pts.					
	Most injured organ	Kidney 62	Small bowel 197		Small bowel 241
	2nd most injured organ	Liver 45	Colon 147		Liver 189
	3rd most injured organ	Small bowel 44	Liver 144		Colon 177

PAT indicates penetrating abdominal trauma
SW indicates Stab Wound
GSW indicates Gunshot Wound
Pt./Pts. indicates Patient/s
PW indicates Penetrating wound
BP indicates blood pressure

Table 2. Surgical and non-operative management of 805 patients with PAT

	Parameter	SW (*n*=303) (*n*=303)	GSW (*n*=502) (n=502)	*p-value*	Combined PAT (*n*=805)
Management pathways: *n* (%)					
	Immediate Laparotomy	95 (31.4%)	351 (69.9%)	<0.001	446 (55.4%)
	Non-operative Management [SNOM]	208 (68.7%)	151 (30.1%)	<0.001	359 (44.5%)
	• Delayed Laparotomy [Failed SNOM]	19 (6.3%)	16 (3.2%)	<0.001	35 (4.3%)
	• Managed non-operatively overall	189 (62.4%)	135 (26.9%)	<0.001	324 (40.2%)
	• SNOM success rate [as % of SNOM]	90.9%	89.4%	NS	90.3%
Management adjuncts: *n* (%)					
	Emergency CT scan performed	145 (47.9%)	210 (41.8%)	NS	355 (44.1%)
	Damage Control Surgery	7 (2.3%)	56 (11.2%)	0.004	63 (7.8%)
	Diagnostic Laparoscopy	15 (5.0%)	4 (0.8%)	<0.001	19 (2.4%)
	Interventional radiology performed	25 (8.3%)	48 (9.6%)	NS	73 (9.1%)
Immediate laparotomy					
Indications: *n* (%)	Haemodynamic instability	12 (4.0%)	30 (6.0%)	<0.001	42 (5.2%)
	Peritonitic	42 (13.9%)	254 (50.6%)	<0.001	296 (36.8%)
	Unreliable clinical findings	8 (2.6%)	16 (3.2%)	<0.001	24 (3.0%)
	Radiological finding	11 (3.6%)	46 (9.2%)	<0.001	57 (7.1%)
	Evisceration	22 (7.3%)	5 (1.0%)	<0.001	27 (3.4%)
Results: *n* (%)	Negative	6 (2.0%)	12 (2.4%)	NS	18 (2.3%)
	Non-therapeutic	7 (2.3%)	15 (3.0%)	NS	22 (2.7%)
	Therapeutic	82 (27.1%)	324 (64.5%)	NS	406 (50.4%)
	Missed injuries	3 (1.0%)	12 (2.4%)	NS	15 (1.9%)
Delayed laparotomy:					
Indications: *n* (%)	Hemodynamically unstable	0 (0%)	2 (0.4%)	NS	2 (0.3%)
	Peritonitic	9 (3.0%)	5 (1.0%)	NS	14 (1.7%)
	Radiological findings	4 (1.3%)	6 (1.2%)	NS	10 (1.3%)
	Concern of sepsis	6 (2.0%)	3 (0.6%)	NS	9 (1.1%)
Results: *n* (%)	Negative	2 (0.7%)	1 (0.2%)	NS	3 (0.4%)
	Non-therapeutic	2 (0.7%)	0 (0%)	NS	2 (0.2%)
	Therapeutic	15 (5.0%)	15 (3.0%)	NS	30 (3.7%)
Diagnostic laparoscopy					
Results: *n* (%)	DI excluded	10 (3.3%)	3 (0.6%)	NS	13 (1.6%)
	DI repaired laparoscopically	2 (0.7)	1 (0.2%)	NS	3 (0.4%)
	DI repaired open	3 (1.0%)	0 (0%)	NS	3 (0.4%)

SW indicates Stab Wound
GSW indicates Gunshot Wound
DI indicates Diaphragmatic Injury
PAT indicates penetrating abdominal trauma

Table 3. Outcomes of 805 patients with PAT

Parameter		SW (*n*=303)	GSW (n=502)	*p-value*	Combined PAT (*n*=805)
Mortality	*n* (%)	14 (4.6%)	44 (8.8%)	0.027	58 (7.2%)
Morbidity	Non-fatal complications (%)	41 (13.5%)	138 (27.5%)	<0.001	179 (22.2%)
	Clavien Dindo specified: n (%)				
	Grade 1	7 (2.3%)	15 (3.0%)		22 (2.7%)
	Grade 2	12 (4.0%)	39 (7.8%)		51 (6.3%)
	Grade 3a	8 (2.6%)	25 (5.0%)		33 (4.1%)
	Grade 3b	7 (2.3%)	30 (6.0%)		37 (4.6%)
	Grade 4a	3 (1.0%)	17 (3.4%)		20 (2.5%)
	Grade 4b	4 (1.3%)	12 (2.4%)		16 (2.0%)
	Grade 5	14 (4.6%)	44 (8.8%)		58 (7.2%)
LOS in hospital					
	Days: Median (IQR)	4.5 (3-7)	7 (5-12)	<0.001	6 (4-10)
	LOS > 30 days: *n* (%)	5 (1.7%)	32 (6.4%)	0.002	37 (4.6%)
ICU	Admissions: *n* (%)	23 (7.6%)	93 (18.5%)	<0.001	114 (14.2%)
	LOS Days: Median (IQR)	3 (2-4)	3 (2-5)	NS	3 (2-5)
Relaparotomy < 30 days					
Total	*n* (% of PAT)	10 (3.3%)	66 (13.1%)	<0.001	76 (9.4%)
	n (% of lap.)	10 (8.7%)	66 (18.0%)	<0.001	76 (15.8%)
Unplanned	*n* (% of lap.)	5 (4.4%)	27 (7.4%)	<0.001	32 (6.7%)
Readmission < 30 days	*n* (%)	13 (4.3%)	26 (5.2%)	NS	39 (4.8%)

ICU indicates Intensive Care Unit
LOS indicates Length of stay
SW indicates stab wound
GSW indicates gunshot wound
Lap indicates Laparotomies
PAT indicates penetrating abdominal trauma

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Chapter 3

Appendices

***Appendix 1* - Data Collection Sheet**

- The following data will be exported from eTHR:
    - Patient age:
    - Patient sex:
    - Injury time:
    - Admission time:
    - Mechanism of injury (Stab / GSW):
    - Number of insults (Stab / GSW):
    - Anatomical region of injuries:
    - Admission vital signs (Pulse, Resp rate, BP, Temp, GCS):
    - Comorbidities:
    - Drug use:
    - Intensive care unit (ICU) admission time:
    - ICU discharge time:
    - Laboratory Investigations (Hb, pH, Lactate)
    - Radiological investigations positive findings (CT / CXR)
    - Injury description including AAST injury scoring (*Appendix 1*);
    - Treatment modalities (OM / SNOM):
    - Indication if OM:
    - Morbidities according to the Clavien Dindo Grading System (*Appendix 2*)
    - Discharge time:
    - Mortalities.

- Using this data, the relevant trauma scores *(Appendix 3)* will be calculated:
    - Injury Severity Score (ISS);
    - Penetrating Abdominal Trauma Index (PATI)
    - Revised Trauma Score (RTS)
    - Kampala Score (KTS)

Appendix 2 – Study Ethics Approval

UNIVERSITY OF CAPE TOWN
Faculty of Health Sciences
Human Research Ethics Committee

Room E53-46 Old Main Building
Groote Schuur Hospital
Observatory 7925
Telephone [021] 406 6626
Email: shuretta.thomas@uct.ac.za
Website: www.health.uct.ac.za/fhs/research/humanethics/forms

29 June 2017

HREC REF: 443/2017

Prof P Navsaria
Trauma/Surgery
J-Floor, OMB

Dear Prof Navsaria

PROJECT TITLE: PENETRATING ABDOMINAL TRAUMA: SPECTRUM OF DISEASE IN A LEVEL I TRAUMA CENTRE (MMed candidate- Dr A Sander)

Thank you for submitting your study to the Faculty of Health Sciences Human Research Ethics Committee.

It is a pleasure to inform you that the HREC has **formally approved** the above-mentioned study.

Approval is granted for one year until the 30 June 2018.

Please submit a progress form, using the standardised Annual Report Form if the study continues beyond the approval period. Please submit a Standard Closure form if the study is completed within the approval period.
(Forms can be found on our website: www.health.uct.ac.za/fhs/research/humanethics/forms)

Please quote the HREC REF in all your correspondence.

Please note that the ongoing ethical conduct of the study remains the responsibility of the principal investigator.

Please note that for all studies approved by the HREC, the principal investigator **must** obtain appropriate institutional approval before the research may occur.

The HREC acknowledge that the student, Dr Anthony Sander will also be involved in this study.

Yours sincerely

PROFESSOR M BLOCKMAN
CHAIRPERSON, FHS HUMAN RESEARCH ETHICS COMMITTEE
Federal Wide Assurance Number: FWA00001637.
Institutional Review Board (IRB) number: IRB00001938
This serves to confirm that the University of Cape Town Human Research Ethics Committee complies to the Ethics Standards for Clinical Research with a new drug in patients, based on the Medical

Appendix 3 – Journal Article Submission Guidelines (SAMJ)[1]

Manuscript preparation

Preparing an article for anonymous review

To ensure a fair and unbiased review process, all submissions are to include an anonymised version of the manuscript. The exceptions to this are Correspondence, Book reviews and Obituary submissions.

Submitting a manuscript that needs additional blinding can slow down your review process, so please be sure to follow these simple guidelines as much as possible:

- An anonymous version should not contain any author, affiliation or particular institutional details that will enable identification.
- Please remove title page, acknowledgements, contact details, funding grants to a named person, and any running headers of author names.
- Mask self-citations by referring to your own work in third person.

General article format/layout

Accepted manuscripts that are not in the correct format specified in these guidelines will be returned to the author(s) for correction, which will delay publication.

General:

- Manuscripts must be written in UK English.
- The manuscript must be in Microsoft Word format. Text must be single-spaced, in 12-point Times New Roman font, and contain no unnecessary formatting (such as text in boxes).
- Please make your article concise, even if it is below the word limit.
- Qualifications, ***full*** affiliation (department, school/faculty, institution, city, country) and contact details of ALL authors must be provided in the manuscript and in the online submission process.
- Abbreviations should be spelt out when first used and thereafter used consistently, e.g. 'Intravenous (IV)' or 'Department of Health (DoH)'.
- Include sections on Acknowledgements, Conflict of Interest, Author Contributions and Funding sources. If none is applicable, please state 'none'.
- Scientific measurements must be expressed in SI units except: blood pressure (mmHg) and haemoglobin (g/dL).
- Litres is denoted with an uppercase L e.g. 'mL' for millilitres).
- Units should be preceded by a space (except for % and °C), e.g. '40 kg' and '20 cm' but '50%' and '19°C'.
- Please be sure to insert proper symbols e.g. *μ* not u for micro, a not a for alpha, b not B for beta, etc.
- Numbers should be written as grouped per thousand-units, i.e. 4 000, 22 160.
- Quotes should be placed in single quotation marks: i.e. The respondent stated: '...'
- Round brackets (parentheses) should be used, as opposed to square brackets, which are reserved for denoting concentrations or insertions in direct quotes.
- If you wish material to be in a box, simply indicate this in the text. You may use the table format –this is the *only* exception. Please DO NOT use fill, format lines and so on.

SAMJ is a generalist medical journal, therefore for articles covering genetics, it is the responsibility of authors to apply the following:

- Please ensure that all genes are in italics, and proteins/enzymes/hormones are not.

- Ensure that all genes are presented in the correct case e.g. TP53 not Tp53.

**NB: Copyeditors cannot be expected to pick up and correct errors wrt the above, although they will raise queries where concerned.

- Define all genes, proteins and related shorthand terms at first mention, e.g. '188del11' can be glossed as 'an 11 bp deletion at nucleotide 188.'

- Use the latest approved gene or protein symbol as appropriate:

- Human Gene Mapping Workshop (HGMW): genetic notations and symbols
- HUGO Gene Nomenclature Committee: approved gene symbols and nomenclature
- OMIM: Online Mendelian Inheritance in Man (MIM) nomenclature and instructions
- Bennet et al. Standardized human pedigree nomenclature: Update and assessment of the recommendations of the National Society of Genetic Counselors. J Genet Counsel 2008;17:424-433: standard human pedigree nomenclature.

Preparation notes by article type

- Research
- Editorials
- CME
- In Practice and Case reports
- Reviews
- Clinical trials
- Correspondence
- Obituaries
- Book reviews
- Guidelines

Research

Guideline word limit: 4 000 words

Research articles describe the background, methods, results and conclusions of an original research study. The article should contain the following sections: introduction, methods, results, discussion and conclusion, and should include a structured abstract (see below). The introduction should be concise – no more than three paragraphs – on the background to the research question, and must include references to other relevant published studies that clearly lay out the rationale for conducting the study. Some common reasons for conducting a study are: to fill a gap in the literature, a logical extension of previous work, or to answer an important clinical question. If other papers related to the same study have been published previously, please make sure to refer to them specifically. Describe the study methods in as much detail as possible so that others would be able to replicate the study should they need to. Results should describe the study sample as well as the findings from the study itself, but all interpretation of findings must be kept in the discussion section, which should consider primary outcomes first before any secondary or tertiary findings or post-hoc analyses. The conclusion should briefly summarise the main message of the paper and provide recommendations for further study.

Select figures and tables for your paper carefully and sparingly. Use only those figures that provided added value to the paper, over and above what is written in the text.

Do not replicate data in tables and in text .

Structured abstract

- This should be 250-400 words, with the following recommended headings:
  - **Background:** why the study is being done and how it relates to other published work.
  - **Objectives:** what the study intends to find out
  - **Methods:** must include study design, number of participants, description of the intervention, primary and secondary outcomes, any specific analyses that were done on the data.
  - **Results:** first sentence must be brief population and sample description; outline the results according to the methods described. Primary outcomes must be described first, even if they are not the most significant findings of the study.
  - **Conclusion:** must be supported by the data, include recommendations for further study/actions.
- Please ensure that the structured abstract is complete, accurate and clear and has been approved by all authors.
- Do not include any references in the abstracts.

Here is an example of a good abstract.

Main article

All articles are to include the following main sections: Introduction/Background, Methods, Results, Discussion, Conclusions.

The following are additional heading or section options that may appear within these:

- Objectives (within Introduction/Background): a clear statement of the main aim of the study and the major hypothesis tested or research question posed
- Design (within Methods): including factors such as prospective, randomisation, blinding, placebo control, case control, crossover, criterion standards for diagnostic tests, etc.
- Setting (within Methods): level of care, e.g. primary, secondary, number of participating centres.
- Participants (instead of patients or subjects; within Methods): numbers entering and completing the study, sex, age and any other biological, behavioural, social or cultural factors (e.g. smoking status, socioeconomic group, educational attainment, co-existing disease indicators, etc)that may have an impact on the study results. Clearly define how participants were enrolled, and describe selection and exclusion criteria.
- Interventions (within Methods): what, how, when and for how long. Typically for randomised controlled trials, crossover trials, and before and after studies.
- Main outcome measures (within Methods): those as planned in the protocol, and those ultimately measured. Explain differences, if any.

Results

- Start with description of the population and sample. Include key characteristics of comparison groups.
- Main results with (for quantitative studies) 95% confidence intervals and, where appropriate, the exact level of statistical significance and the number need to treat/harm. Whenever possible, state absolute rather than relative risks.
- Do not replicate data in tables and in text.
- If presenting mean and standard deviations, specify this clearly. Our house style is to present this as follows:
- E.g.: The mean (SD) birth weight was 2 500 (1 210) g. Do not use the ± symbol for mean (SD).
- Leave interpretation to the Discussion section. The Results section should just report the findings as per the Methods section.

Discussion

Please ensure that the discussion is concise and follows this overall structure – sub-headings are not needed:

- Statement of principal findings
- Strengths and weaknesses of the study
- Contribution to the body of knowledge
- Strengths and weaknesses in relation to other studies
- The meaning of the study – e.g. what this study means to clinicians and policymakers
- Unanswered questions and recommendations for future research

Conclusions

This may be the only section readers look at, therefore write it carefully. Include primary conclusions and their implications, suggesting areas for further research if appropriate. Do not go beyond the data in the article.

References

(1) SAMJ Article Submissions Guidelines. Available at: http://www.samj.org.za/index.php/samj/about/submissions#Layout. Accessed 11 Nov, 2018.